Lecture 3: Plankton, benthos, biomass assessment

Plankton

Live organisms, essentially microorganisms those drift, or are visibly mobile are referred to as plankton.

The term ‘plankton’ was coined by Victor Hensen in 1887.Plankton, by virtue of drifting habit and short turnover period, constitutes the major link in the food chain in the reservoir ecosystem. Plankton provides about 50% of total food required for the fish. Due to their balanced nutritional content, plankters are referred to as ‘living capsules of nutrition’. These food organisms are broadly categorized as phytoplankton and zooplankton.

Phytoplankton

Phytoplankton are the microscopic plant life of any water body which forms the primary producers synthesizing the basic food to almost all the animals in an aquatic ecosystem. They form the basic live feed to all the zooplankton and larval forms of crustaceans, molluscs and fishes. Their importance lies in the fact that they are photosynthesizing organisms and serve as first link in the food chain. They belong to the Class Algae which besides chlorophylls possess other characteristic pigments. Most phytoplankton organisms are unicellular, some are colonial and filamentous in habit. Phytoplankton in reservoirs include both pelagic and (attached) benthic algae that have broken off from the bottom. By major taxonomic category, the following traits are characteristic of each major taxon:

Diatoms (Bacillariophyceae):

These mostly non-motile organisms may be pelagic(suspended in the water column) or benthic (attached to or residing on the bottom of lakes). Diatoms are considered desirable because of their value as food sources for the rest of the aquatic food web.

Chlorophytes:

These “green” algae are a diverse group that includes forms considered ecologically desirable (i.e., suitable for grazing by crustacean zooplankton) as well as those that are not (e.g., flagellated forms and eutrophic indicator species such as *Cladophora* spp.). Some make colonies surrounded by a gelatinous matrix that can be eaten by zooplankton, but pass through the gut undigested. It is difficult to generalize regarding this group, as they range in size from very large to very small, some are mobile, and many are not.

Blue-green algae (Cyanophyceae) :

This major category of phytoplankton known as the “blue-green algae” has certain species that may produce toxins harmful to humans and animals in some circumstances. They are more bacteria-like than plant-like, but since they may photosynthesize, they are included with the phytoplankton. They can alter the entire structure of the food web in a lake when they become prevalent, and are generally considered as less desirable or noxious species. Besides toxins, some forms are filamentous and therefore less desirable for grazing by many forms of zooplankton. Extensive studies of these properties have been conducted, but the factors that triggers or control toxin production and the suitability of various types of blue-greens as crustacean zooplankton food are still a research issue. Blue-green algae from the mainstay of plankton community in vast majority of the reservoirs studied. The overwhelming presence of *Microcystis aeruginosa* in Indian reservoirs is remarkable. The productive water of Gangetic plains, Deccan plateau, south Tamil Nadu and Orissa invariably has good standing crop of *Microcystis*. The species is almost omnipresent in the southern Peninsula, except in the reservoirs of Karnataka and Kerala, which tend to be oligotrophic and have poor plankton count with desmids and other green algae as the main constituents.

Dinoflagellates: Dinoflagellates are motile, heterotrophic, or autotrophic forms that can be considered midway between plant and animal kingdoms. They can form extensive blooms in fresh and salt water, but are typically more of a problem in marine coastal areas where they may cause red tides or harmful algal blooms.

Zooplantkon

Zooplankton are planktonic animals that are the primary consumers of phytoplankton. They are important food web components in the reservoir ecosystem for larval, juvenile and even larger fishes.

The zooplankton communities in reservoir ecosystem are not species enriched. The principal constituents of zooplankton are rotifers, cladocerans, copepods and protozoans. Some of the food organisms include the rotifer (*Brachionus, Keratella*). Copepods (Diatoms and Cyclops) and cladocerans (*Daphnia* and *Moina*). They have high reproduction rate, short generation time and have the ability to grow and live in crowded conditions.

Copepods: The copepods constitute one of the important components of the food chain in aquatic ecosystem. Planktonic copepods consist of two major groups, the calanoids and the cyclopoids. Along with cladocerans, they are the principal food of a whole series of freshwater fishes. The most common

and important ones are the *Cyclops* spp. And *Diaptomus* spp.
Rotifer : Rotifers are very small microscopic animals found in large numbers in the planktonic fauna.
When abundant in a water body they are generally indicative of detritus-based food webs that may be eutrophic or approaching eutrophy. Most of the rotifer forms are well known food of freshwater fishes.
Fry and small fishes eat rotifers. Among them *B. calcyflorus* and *B. rubusta* have been proposed as food for fishes. *B. plicatilis* have become one of the important components in fish hatcheries.
Cladocerans: Cladocerans are one of the most important of the zooplankton groups, which is good natural food for fishes. The lower crustacean is the principal food item of plankton and is eaten by fry and young fish and also by adults in plankton eating fishes like Catla. Adult carnivorous fishes consume the higher crustaceans. The most common and important ones are the *Sida, Alona, Daphnia,* and *Bosmina* etc.

Benthos

The benthos occupies an important position in the reservoir ecosystem and it plays a key role in the food chain, which in turn affects the cycling of minerals hence as a component of fish food in an aquatic ecosystem, the benthos assumes great significance.
Benthic invertebrate fauna show an erratic distribution in Indian reservoirs. The main factors that retard this community are the predominantly rocky bottom, frequent water level fluctuation and the rapid deposition of silt and other suspended particles. In spite of this, a number of reservoirs harbour rich communities of benthic invertebrates. The distribution of benthic organisms depend on (i) physio-chemical characteristics of water (ii) the nature of sediment (iii) the biological complexes such as food, predation and other factors. The benthic organisms are also distributed according to the zones of l a k e f l o or wh i c h inc l u d e s t h re e z on e s viz . , s u b- l i t t o r a l an d p r of u n d a l . T he v a r i o us zoobenthos encountered in reservoirs of India the freshwater ecosystem is generally divided into two categories – lotic and lentic type.

(a) Benthos of lotic system:

Benthic communities of lotic environments have gained considerable importance as it contributes towards the organic production besides serving as main source of fish food.
The abundance of benthos is directly related to the availability of food supply in the form of decaying organic matter. This is in consonance with the fact that the benthos, particularly oligocheates are related to detritus and detritus in turn, to plant production. S e v e r a l o t h e r f a c t o r s l i k e amo u nt o f s u ns h i ne , d i s s o l v e d c a l c i um a n d v e ge t a t i o n a r e further responsible for the increase of population, which ultimately constitute the fish

food.

(b) Benthos of lentic system:

T h e l e n t i c be nt h o s sh ows a r ema r k a bl e d e c r e a s e wi t h t he i nc r e a s e of a l t i t ud e .

Certain other ecological factors l ike eutrophication, pollution, quality and quantity of aquatic vegetation, texture of lake substratum the physico-chemical features of water etc affect the distribution and relative abundance of benthos. The period of abundance of aquatic Hemipterans coincides with the spawning period of some important fishes. Some of the macro invertebrates occur in association with certain species of aquatic rooted plants viz., *Ceratophyllum, Myriophyllum, Hydrilla* and *Potamogeton*.

Phytobenthos: The phytobenthos comprises of epiphytic algae and aquatic soil fungi. The algae consisted of Cyanophyceae Chlorophyceae, Bacillariophyceae, Xanthophyceae, Chrysophyceae, Dinophyceae, Cryptophyceae and Euglenaceae.

Zoobenthos: The majority of zoobenthos in detritus food chain mostly exhibit diverse feeding habits depending upon the trophic status. The basic source of food in the form of detritus is supplied by the annual litter besides other important sources such as animal waste and organic matter transported to the system. In the next level of trophic system are microbes like bacteria and fungi which act as primary decomposers (directly feeding on detritus),forming an organic detritus microbe complex. The quantitative role of decomposers onthe break down process is, however, unknown.

Besides primary decomposers (snail) ,zoobenthos (*Chironomus*) partly takes the role of secondary decomposers and thus some animals play the duel role of primary as well as secondary decomposers (eg.*Chironomus*). These animals are finally the source of food for benthic predators thus completing the detritus food chain. The benthic community succession especially that of chironomids is sometimes used to characterize habitat changes.

Chironomid larvae form the most important constituent of benthos, reported from all soil types and geographic locations and depths. Gastropods and annelids from the next important groups. *Viviparus bengelensis* enjoys countrywide distribution. The sequence of dominance of benthic communities closely fol lows the soil ferti lity pattern, the pre-impoundment debris often providing suitable habitats.

Factors affecting the abundance and distribution of benthos

High shorel ine development, variable slopes and vegetation act as favourable f a c t or s f o r t he d e v e l o pme n t o f a r i c h a s s emb l a g e o f be n t hi c o r g ani sms . B e s i de s t h e physico-chemical parameters of water and soil, the morphometry and hydrography also influence the benthic community. The water level fluctuations limit the colonisation of b o t t o m i n h a b i t i n g o r g a n i s ms . T h e a n n u a l w a t e r r e n e w a l a s w e l l a s t h e

i n c omi n g floodwaters affect and dislodge the bottom fauna. Some of the organisms, the population
is relatively high, but then species adopt to bottom dwelling the deeper profundal region is very small.
On the contrary, the shallow littoral zone has rich diversity of bottom fauna. Most of the fishes including major carps and catfishes are feeding on the bottom at varying degrees of intensity.
Hence, a detailed knowledge of the composition, distribution and seasonal abundance of the bottom fauna is prime requisites form the fisheries point of view.
The abundance of benthos is determined generally by weed infestation, sedimentation, and pollution. Excessive deposition of sediment at the bottom of water h ampe r t h e g r owt h o f b e n t h i c o r g a ni sms . Po l l ut i o n f r om i n d us t r i a l , mu ni c i p a l a n d agricultural
effluents directly influence the bottom fauna. If any peripheral area of the lake or reservoir is converted into agricultural field, a direct threat of pollution from pesticides is definite.
S ome g r o up o f a nima l s wh i c h ha v e a wi de ba t hyme t r i c a l di s t r i bu t i o n e g . Chironomids and Oligochaete, increase in their abundance in the total fauna, while the l i t t o r a l ge t r e duc e d . Th e p h e nome na a r e d ue t o mi g r a t i o n , wh i c h ma y b e
a c t i v e or passive, the latter case is influenced by other factors. The dissimilarity i f any, in the bathymetrical distribution is due to the mobility of the particular species. The gastropods mainly
utilize detritus and algae and adapt themselves to thin depth zone.
The bottom fauna distributed in Karnataka was mainly chironomus fol lowed by Molluscs (*Lamellidens marginalis, L. corianus, Viviparus bengalensis, Thiara tuberculata, Lymnea luteola, L. acuminata and Indoplanorbis exustus*), oligochaetes and prawns. Insect group included mainly mayfly nymphs, dragonfly nymphs,Chaoborus and Caddisfly larvae. These forms are wel l utilized by fishes particularly *P . k ol u s , P . sarana, P. dubius* and catfishes like *M. aor, M. seenghala, M. cavasius* and *S. childreni* as food items.
Benthic Organism: An organism that lives on or in the bottom of an aquatic ecosystem. It feeds on the
sediment at the bottom of a water body such as an ocean, lake, or river.
Definition of Benthic Zones: The word "benthic" is an aquatic term that's used in association with
anything at the bottom of a body of water. Animals and plants that live on or in the bottom are called
benthos, and there are innumerable habitants that occupy the different depth levels of the water floor.
The levels are divided into zones called, Benthic Zones, and each zone is home to specific habitats and
plants, and each bears its own characteristics that come with the particular depth.
How Zones are Determined : The zones of the marine benthic habitats are mapped out according to the

depth of the water. These zones include the Hadal zone, which is over 6,000 meters deep; the Abyssal zone, which is 2,000 to 6,000 meters; the Bathyal zone, which is 200 to 2,000 meters, and the Nearshore and Estuarine zones which are less than 200 meters.

Why Benthic Zones are Important: Each zone is part of the big picture in nature's life cycle and the ecology of wildlife. The shallow zones, which support spawning, are a nursery, a refuge and foraging grounds for fisheries species. Other zones produce coral reefs and eelgrass beds that shelter and protect other species. The recycling of habitats acts as a water filter, removing water contaminants and helping to keep the body of water as a whole clean. The Near shore zones are not only nesting grounds for small organisms--they are the food sources for the other zones as well as for birds.

Biomass

Definition (2):

1. Quantity or weight of all living matter in a given area or biological community.
2. Organic matter available on renewable basis, such as agricultural crops, aquatic plants, animal, municipal, and wood wastes.

Lecture 4: Food and Feeding Habits of Fish

Food habits and feeding ecology research are a fundamental tool to understand fish roles within their ecosystems since they indicate relationships based on feeding resources and indirectly indicate community energy flux (Yánez-Arancibia & Nugent 1977, Hajisamaea *et al.* 2003), which allows inferring competition and predation effects on community structure (Krebs 1999). Other resources such as space and time have also been important for community ecology and the ecological theory predicts that resource partitioning at spatial, temporal and trophic level may increase tolerance of niche overlap reducing competition pressure between co-occurring species. Ross (1986) identified that in aquatic environments food is the main factor and that its partition defines functional groups within the community, which get together in guilds according to trophic similarity.

These trophic guilds (Root 1967) seem to be a consequence of such resource partitioning, which could explain how several species can coexist in the same space by differing in use of several resource dimensions. Several studies have focused on competitive exclusion and resource partitioning in teleost fishes (Zaret & Rand 1971, Hixon 1980, Ross 1986) and have found that habitat partitioning could be related to high dietary overlap among competing species or to interactive competition, where competing species have the same preference by preys (Hixon 1980, Jansen *et al.* 2002).

Feeding habits of some important fishes

Food relationships do at least in part determine the population levels, rates of growth and condition of fish. They serve as a partial basis for determining the status of v a r i o us p r e da to r y or c ompe t i n g f o rms . F or an y s pe c i e s , f o od h a bi t s ch an ge wi t h t h e season, l ife history changes and the kind of food avai lable. Food composition in the gut of fishes are very important basic inputs in various modeling tools and could provide useful information in positioning of the fishes in a food web in their environment and in formulating management strategy options in multi species fishery. The data on stomach comp os i t i on of f i s h i s v i t a l i n p r ov i di n g s t r a i g h t f o rwa r d mod e l s o f s t oma c h c o nt en t dynamics.

Catla catla

C a t l a i s p r e d omi nan t l y a pl a nk t o p h a g i c s u r f a c e f e e de r h a v i n g p re f e r e nc e f o r crustaceans and algae. Based on periodic availability of food, catla changes over to more p l a n t f o o d f r om a n i m a l f o o d a n d v i c e v e r s a . F o r p l a n k t o n f e e d i n g h a b i t a g r e a t inters-pecific food competition is seen in catla with almost all the inhabiting species at fry stage as they all mainly prey upon the plankton. The minnows and clupeids are the main competitors of catla in reservoirs.

Labeo rohita

Rohu is predominantly a surface feeder and planktivore in the fry stage. Rohu forms a great inter-specific competitor with almost all other inhabiting carp species at the earlier stages of life. But this competition is considerably reduced from fingering stage o nwa r d s wh e n r oh u c ha n ge s t h e f e ed i ng h a bi t a n d ha bi t a t , b e c ome a c ol umn- b o t t om feeder and start consuming food mainly the fi lamentous algae, mud and sand. Rohu is found to be a herbivorous fish, consuming more than 75% plant food (unicellular algae a n d f i l ame n t ou s a l g ae) a n d t h e r ema ini n g r e p re s e nt e d b y a n ima l fo o d (br y oz oa ns , rotifers, insect larvae and crustaceans). The dominant occurrence of algae and submerged vegetation in the gut indicates the column feeding habit while the presence of decayed organic matter and mud supports the bottom feeding habit too.

Cirrhinus mrigala

Mrigal is predominantly a bottom feeder in adult stage but surface and mid-water feeder in fry and fingerl ing stages. The long intestinal coil in the adult is found to be more suitable for digestion of the vegetable matter and detritus in the food item. The gut contents are mainly comprised of decayed organic and vegetable debris, phytoplanktonic organisms and mud.

Cyprinus carpio

Common carp is an omnivorous and it has wide food spectrum. It can adjust the dietary habit according to the local availability of natural food. It is not usually a plankton f e e de r b ut t he y a re s ome t ime s f o un d f e e di ng on z oo pl a nk t o n i f i t i s a bu n da nt i n t h e environment. It has in general a preference for bottom flora and fauna (Chironomidae, Ephemeridae, Crustacea, Mollusca and Trichoptera). Fingerlings normally switch over tocolumn and bottom dwelling food organisms. Feeding intensity is found to vary with thewater temperature.

Ctenopharyngodon idella

Grass carp at larval stages feeds on plankton with preference to nanoplankton, rotifers and small-sized cladocerans. But they quickly switch over their feeding habits on macrophytes entirely. The feeding intensity during post spawning months is high and the adults consume *Hydrilla, Vallisneria, Najas, Utricularia* and soft leaves of *Eichornia*.

Hypothalamicthys molitrix

Silver carp is a planktivore. The young and adult exhibit almost similar feedingha bi t s wi t h ma j o r d e p e n d en c e on *Spirulina, Osci llatoria, Chlorel la, Microcystis* and dominance on *Desmidium, Cosmarium, Staurastrum, Synedra*, and *Fragilaria*.

Puntius spp.

The presence of wide variety of food items in the diet of these cyprinids, indicates a n omn i vo r ous f e e di n g ha bi t . De t a i l ed d i e t a r y c omp o s i t i o n a l s o s h owe d t ha t a l l a r e omn i v o r o us , b ut mor e d e p e n d en t o n be n t hi c f o o d i t ems . Bu t t he pr e s en c e of i n s e c t matters, microbenthos, mol luscs and crustacean in large biovolumes indicates that both *P . c h o l a* and *P. dorsalis* are insectivorous, and benthivorous fish, while *P . s ar a n a* is molluscivorus and insectivorous. Furthermore, the preference on benthic matter by *P.chola* and *P. dorsalis* indicate their bottom feeding habit. The preference on mollusc and insect matter in *P. sarana* indicates their ability to feed throughout water column.

Mystus spp.

M. aor in general is a zooplankton feeder at an early stage but the feeding a bit changes to animal organisms (fishes, may-fly nymphs, molluscs and oligochaetes) in the adult stage. Juveniles are mostly insectivorous and marginal feeders.

M. seenghala is a bottom and column feeder, predominantly a carnivore right from the advanced fry stage t o a d u l t . F i s h i s t h e m a i n f o o d i t e m t h o u g h i t c o n s um e s g o o d q u a n t i t y o f i n s e c t s depending upon the availability in the environment during different seasons.

Wallago attu

This is an extremely voracious carnivore, feeds predominantly on fish. Insects, crustacea and algae are sometimes encountered in the gut. Fingerl ings consume insects, other fish fry and fingerlings. The food of freshwater fish species is a subject of continuous research because it constitutes the basis for the development of a successful fisheries management programme on fish capture and culture.